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NASA GATEWAY REQUIREMENTS
ANALYSIS

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Executive Summary

NASA GATEWAY REQUIREMENTS ANALYSIS

The National Aeronautics and Space Administration (NASA) Scientific and Technical Information (STI) Division in the Office of Management has recently formulated its strategic vision. That vision emphasizes developing a program that focuses on the customer, and it establishes the STI Program as an integral part of NASA's R&D effort. To implement the vision, the STI Division must understand the NASA R&D community's information requirements, review sources of the relevant information, and examine ways of facilitating access to them.

NASA devotes approximately 40 percent of its budget to R&D. Twelve NASA Research Centers and their contractors conduct this R&D, which ranges across many disciplines and is fueled by information about previous endeavors. Such information can be in the form of personal notes and communications, publications, and data that are available from repositories in the field. Locating the right information is crucial. While NASA researchers use peer contacts as their primary source of STI, on-line bibliographic data bases – both Government-owned and commercial – are also frequently consulted. Once identified, the STI must be delivered in a usable format.

We found that NASA researchers need more comprehensive STI coverage of disciplines not now represented in NASA's Remote Console (RECON) bibliographic data base – disciplines such as engineering, physics, geology, mathematics, electronics and control systems, materials, patents, and life sciences. This augmented subject coverage should preferably be provided by both domestic and foreign STI sources. We also found that NASA researchers frequently request rapid delivery of STI, in its original format. Finally, we found that they need a better system for alerting them to recent developments in their areas of interest.

A gateway that augments RECON subject coverage and affords access to full-text data sources can solve several shortcomings in the present STI delivery system. NASA should further test the practicality of a gateway as a first-choice mechanism

for improved STI access. Specifically, we recommend that NASA take the following steps:

- Select a limited set of STI sources that represent the variety of available STI and have high relevancy to the NASA R&D user community
- Allow users to evaluate the utility of access to those STI sources by making available a prototype intelligent gateway for users to test for 6 months
- Provide the most frequently requested applications in the prototype gateway
- Install the prototype in Research Center libraries and selected end-user offices and use a tested telecommunications link to the selected STI sources.

At the conclusion of this test, NASA's STI Division can better judge how to continue — with optimum use of gateway technologies and features — expanding access to STI across more disciplines and sources to a wider user community.

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CHAPTER 1

BACKGROUND

The Scientific and Technical Information (STI) Division in the Office of Management of the National Aeronautics and Space Administration (NASA) is revamping its services, products, and systems to look beyond the year 2000. The strategic vision document recently prepared by the division states that the "focus of our effort will be the development of a global program to encourage the creation and exchange of STI and facilitate its use . . ." Two of the nine strategic goals developed to achieve the mission seek to

- Enhance the quality of STI products and services through a focus on the customer
- Establish the STI Program as an integral part of the NASA R&D effort.

To implement its strategic vision, the STI Division must understand the linkage between the R&D programs and the supporting STI services and products. NASA devotes approximately 40 percent of its budget to R&D. Twelve NASA Research Centers and their contractors conduct that R&D, which ranges across many disciplines. In addition, NASA has entered into cooperative projects with other U.S. Government agencies and with other nations. This R&D environment is extremely complex and interdisciplinary in nature. What is critical to remember for implementing the division's strategic vision is that R&D is fueled by information about previous endeavors. Locating and delivering the right information to the R&D community is a large part of the STI Division's mission.

To link R&D programs to the STI Program, the STI Division needs to have knowledge of

- The information requirements of the R&D community
- The relevant information sources to meet those requirements
- Ways of facilitating access to those information sources.

To achieve complete understanding of these areas would require a comprehensive review of the STI Program. The study we performed supports one objective in the STI Division strategic plan — the provision of new tools for STI utilization by their user community. One such tool is an intelligent gateway, a system that assists users in locating and retrieving information from STI sources. This report assesses the appropriateness of developing an intelligent gateway interface for the R&D community as a means of obtaining improved access to relevant STI resources outside of NASA's Remote Console (RECON) on-line bibliographic data base. The assessment addresses the three areas listed previously and maintains a focus on the user; the recommendations in the report should complement future customer-focused efforts of the STI Division. The discussion of findings in Chapter 5 provides the context for a better understanding of the STI user environment.

USERS OF NASA STI

The STI Division needs to understand the composition of the market for its products and services. Since NASA's charter includes the dissemination of information to other government agencies and to the commercial sector, this market is large and diverse. Some users retrieve STI to support NASA research. They include NASA employees and support service contractors (primarily scientists and engineers) and also NASA information brokers (such as librarians, Industrial Applications Centers, and Technology Utilization Offices). Other users are universities, commercial aerospace R&D organizations, and worldwide peers in aerospace research.

User interviews at three NASA Research Centers — Ames, Langley, and Lewis — were coordinated through the Centers' STI managers and typically included the Center's library staff, STI production staff, and end users selected by the STI manager. Further details on the scope and methodology of selecting and interviewing users for this report can be found in the Appendix.

STI TYPES AND RESOURCES

R&D activities may require STI that is not in text or bibliographic form (for example, specifications, drawings, numerical data, photographs, video images, tables, and formulae). We discussed and identified the composition of STI needed by NASA R&D users so that the STI Division can provide an optimum mix to its

customer, or user, base. This analysis provides needed direction in selecting the most relevant STI for the gateway prototype.

RECON provides bibliographic citations to nearly all NASA-sponsored research reports, to selected reports from other research institutions, and to selected journals in the aerospace field. However, NASA's R&D program covers subjects in addition to aerospace. STI is generated and stored in many places and is distributed by diverse mechanisms (for example, peer contact, professional society symposia, papers and journals, and on-line data bases). Therefore, a broader range of coverage in additional disciplines and from more STI resources may be needed if NASA STI requirements are to be met fully. Details of the results of our analysis can be found in Chapter 4.

STI DELIVERY SYSTEMS

Currently, most of the information products and services provided by the STI Division are derived from RECON. Users can request (or directly conduct) queries of RECON. Requested queries are usually performed by a Center's library staff. The result is a printout of citations to documents whose full text may be in the Center's library or on microfiche kept at the NASA STI Facility (STIF).

Much of the STI distributed by other mechanisms outside of NASA may be available in more useful formats with faster delivery. The STI Division must determine the advantage to the users of providing STI through alternative delivery mechanisms that may be more useful and handle more diverse STI formats.

ASSUMPTIONS AND CONSTRAINTS

The following assumptions and constraints affected this feasibility study for a NASA gateway:

- While RECON is treated as any other STI resource, it is uncertain whether RECON or RECON II will be available for access via the gateway.
- This report reflects the input of only a sample of the NASA R&D community. While this sample included three Research Centers, it did not involve any of the Space Flight Centers.
- Many networks and hardware platforms are used in the NASA R&D environment. The STI Division cannot control or change them but must work within those architectures.

- The gateway must be developed in concert with electronic mail and networking initiatives under way in the STI Division.
- The domain of STI resources outside of NASA will change. Again, NASA must work with these changes and keep the gateway flexible.

CHAPTER 2

SUMMARY OF USER REQUIREMENTS

Although potential STI end users interviewed represented many disciplines and research perspectives, there was a high degree of consistency in their responses regarding the functional requirements of an improved STI delivery system. The requirements common to the majority of interviewees can be grouped in three areas:

- Broader and deeper coverage of relevant disciplines
 - ▶ Comprehensive coverage of the disciplines in which NASA performs basic and applied research
 - ▶ At a minimum, improved subject coverage of engineering, physics, geology, mathematics, electronics and control systems, materials, patents worldwide, and life sciences
- Improved identification of information sources
 - ▶ Access to numerical data sets resulting from previous observation-based research
 - ▶ Location and retrieval of pertinent STI from all major foreign sources
 - ▶ Where full gateway access to a source is not feasible, better location of sources of STI within NASA, within the United States and internationally
- Improved access to information sources
 - ▶ Improvement in telecommunications external to the NASA Center (for example, simplified mail across mail systems and networks)
 - ▶ Rapid retrieval of full text of STI, with graphics intact, through the STI delivery system
 - ▶ Access to STI via a query structure that is not text oriented (for example, by performance parameters or chemical structure)
 - ▶ Increased information on and access to Internet resources
 - ▶ Capability to execute simple STI data base queries from the researcher's desktop system

- ▶ Access to some Center library services without leaving one's building
- ▶ A current awareness system (alerting the user to recently available STI matching the user's interest profile) that an end user can easily modify and execute
- ▶ Electronic browsing of STI sources and query results
- ▶ Simplified access to text translation services (allowing a citation to a published item retrieved through the STI delivery system to be sent to a translation service via the same system).

CHAPTER 3

ALTERNATIVES AND RECOMMENDED ACTIONS

There are several alternatives for providing the ability to locate the right information and deliver it to STI users. One alternative is to provide a gateway system to the NASA STI user community, similar to the Defense Gateway Information System provided to the DoD user community. This alternative has the advantage of being a proven commodity, but it has several disadvantages: it is high risk (because the user environments differ in many respects), is expensive to deploy, and will be subject to the delay inherent in large-system development. A second alternative is to test a smaller gateway with a sample of the STI user community. This alternative, which we recommend, is explored in more detail below. A third alternative, of course, is to continue with the status quo; however, our assessment is that the current delivery system is failing to meet the R&D community's needs.

The following recommended actions should benefit several areas affecting the delivery of NASA STI. They are intended to assist the evaluation of the utility of using gateway technology as part of the larger STI delivery system, improve STI support to researchers in the near term, and advance the implementation of the STI Division's strategic vision.

Action Item 1: Provide a prototype intelligent gateway for user testing for a minimum of 6 months to allow users to evaluate the utility of access to new STI sources.

- Users need quicker and easier access to more diverse sources of STI. For example, users need to query sources that accept a chemical structure diagram as input.
- Only users (both end users and librarians) can evaluate the quality and usefulness of STI available from those sources.
- Only users (both end users and librarians) can judge a user interface as to its ease of use and the adequacy of search capability it provides.

- The frequency of users accessing STI now ranges from once every 2 weeks to once every 3 to 6 months. This frequency is related to the cycle of research initiation and report writing. A minimum of a 6-month test period is needed to allow very infrequent users to test the system under real-world conditions.
- The prototype will provide a mechanism for end users and library staff to evaluate STI sources and communicate their evaluation to NASA Headquarters. Since the number of sources is growing rapidly, NASA may wish to use this mechanism for source evaluation on a continuing basis.

Action Item 2: Select a limited set of STI sources representing the variety of available on-line STI and having the highest relevancy to the prototype user community. These should include a source of information on research performed outside the United States; RECON; a source of chemistry, materials, physics, engineering, and patent information; Internet resources; and access to human resources, such as the larger Internet research community and the STI Division staff.

- By careful selection of sources, NASA can – with only a limited investment in interface development – provide coverage of many of the subject areas of interest to the user community. This will allow users to evaluate the concept of on-line access for some subject areas and to extend that concept to other subject areas.
- User awareness of foreign sources of on-line STI is low. The utility of increased availability of foreign STI should be evaluated by NASA researchers.
- RECON should be the best source for internally produced STI. For a comprehensive evaluation of on-line STI, RECON should be evaluated under the same conditions as the other sources.
- Users routinely need access to commercial data bases for chemistry, materials, physics, engineering, and patent information. This requirement should be addressed by the prototype.
- Peers were consistently cited as critical resources in the location and use of STI. Internet provides access to a larger research community and utilities required in NASA research.
- The STI Division should participate in the gateway evaluation and is needed as a resource for the Center librarians.

- Some on-line sources require a subscription and fees for their use. The prototype should be as low cost as possible while still providing a comprehensive evaluation of user access to on-line STI.
- Limiting the set of prototype sources allows users to focus on evaluating the concept of direct access to on-line STI; including too many sources will add too many variables to be evaluated.

Action Item 3: Include in the gateway prototype the applications most frequently requested by users. There should be a two-level user interface: one level for end users and one for NASA library staff.

- End users consistently requested improved access to journals, simplified current awareness queries, better access to their peers, and simplified access to Internet utilities.
- Librarians frequently requested more consistent access to on-line sources and access to a wider variety of sources, with simple, robust telecommunications.
- Librarians also requested simplified communications with the office that represents their interests at the Headquarters level.

Action Item 4: Base the prototype in Center libraries and selected end-user offices.

- Existing patterns of STI search behavior include the libraries most of the time. End users recognize the libraries as the place to go for new information on STI available on line.
- Having an end-user workstation in the Center library allows the prototype to reach more end users at a lower cost than would supporting many installations in end-user offices.
- The librarians will require an interface different from that provided to the end users; the Center library will be the location where both interfaces can be presented to provide a full understanding of the range of gateway functionality.
- Using the Center libraries in prototype testing builds on one of the strengths of the existing delivery system, the library staffs. The staff will be able to evaluate the librarian's interface and also offer suggestions for improving the end user's interface.

Action Item 5: Using existing networks, provide simplified, reliable telecommunications paths connecting user workstations, the gateway host, and remote sources.

- The various workstations in user locations can be used in gateway access to STI.
- Navigating multiple networks between the user and the desired STI source discourages STI use at both the information-broker and end-user levels.
- Existing NASA networks, both local area networks (LANs) and wide area networks, offer capacity for gateway communications but vary in reliability and accessibility. Those networks could be supplemented by a single commercial system leased for the duration of the prototype test.

Action Item 6: Include all organizations that participate in STI delivery and use in gateway development.

- Researchers have valid ideas regarding the design of the user interface; this group is collectively one of the "owners" of the system and should actively participate in design activities.
- Development of a gateway prototype is a valid R&D function. As such, it would benefit from enhanced communication among the STI Division, the Center libraries, and the R&D community.
- As an R&D project in information retrieval, the gateway supports the achievement of one of the STI Division's strategic goals. A portion of the support for this activity might properly come from R&D areas.

CHAPTER 4

CONCLUSIONS AND SUPPORTING FINDINGS

In this chapter, we list the detailed findings leading our analysis to each conclusion; the findings are grouped under the conclusions to which they relate. These conclusions further lead to the study's recommended actions, which can be reviewed in Chapter 3 and are restated below.

Action Item 1: Provide a prototype intelligent gateway for user testing for a minimum of 6 months to allow users to evaluate the utility of access to new STI sources.

Conclusions: The primary users of STI are NASA researchers and librarians; they are the most qualified evaluators of STI and its utility. We conclude that NASA end users and librarians are accordingly the most logical evaluators of an intelligent gateway as part of the STI delivery system. Also, NASA researchers should participate in design of the STI delivery system and should have a continuing role in quality control of STI provided by the delivery system. A number of findings support these conclusions:

- STI directly supports the research function.
- Researchers are the best judges of data quality and validity and of source credibility.
- Researchers must see the sources and the data they provide to evaluate the utility of those sources and the STI provided.
- Non-NASA end users and information brokers will be satisfied with source data quality if NASA researchers are.
- Non-NASA end users will be satisfied with the gateway user interface if researchers are.
- Librarians also need access to a broader range of bibliographic sources.
- Librarians are well versed in STI required by research communities at their Centers. They could perform preliminary evaluation of sources and data proposed for their users.

- Users should play a continuing role in evaluating new sources for gateway access.
- NASA end users would like more convenient access to library services. With a common system, users can more easily communicate with the library staff.
- Librarians are professional evaluators of information.
- It is impossible to project benefits and costs for the STI delivery system for the long term until users can judge the quality of the information to be delivered, its availability and ease of use, and the effectiveness of the delivery system overall. The degree to which the system meets the requirements will influence the level of use.
- End users have reported no exposure to the intelligent gateway concept.
- A prototype will allow users to evaluate sources, data, and access under real-world conditions.

Action Item 2: Select a limited set of STI resources representing the variety of available on-line STI and having the highest relevancy to the prototype user community.

Conclusion: NASA researchers need access to more diverse sources of STI and need flexibility to add new sources when needed.

- The data in NASA's RECON system are limited as to the scope of subject areas covered, by the query interface, and in the STI delivered.
- Researchers find the STI available from diverse on-line sources useful and timely but, in general, are unaware of the variety of STI available on line.
- Researchers want access to their peers in the research community. Internet is a valuable conduit for peer contact, but users need assistance in using its resources.
- Researchers have identified a trend toward more project-driven research (as opposed to basic research). This research is intrinsically more technology-dependent. New sources of STI on new technologies will appear frequently, and researchers must have the tools to exploit them.
- As research projects grow larger and more expensive, more research will be collaborative. For example, the National Aerospace Plane (NASP) is a collaboration involving NASA, DoD, and commercial aerospace companies, and Earth Observing System (EOS) is an international collaborative effort. Collaborative research requires access to sources located in a variety of organizations and locations.

Conclusion: The STI delivery system must provide access to STI that provides good coverage of relevant research produced outside the United States; RECON; better coverage of chemistry, engineering, materials science, physics, and patent information; STI that is not textual in format and covers a relevant research subject; and Internet resources.

- Because much research worthy of notice is performed beyond the U.S. borders, much relevant STI is generated and stored overseas.
- Electronic STI that is nonbibliographic (this STI is more "reusable" than text is) is increasing as more powerful workstations enable researchers to create data bases, animation, and graphics.
- Organizationally independent research communities currently share data, located through peer contact, across the Internet. While peers provide data to those in their research community fairly freely, it is difficult to locate these peer sources when they are outside one's own research community.
- Commercial data base vendors respond quickly to market demands, providing on-line versions of professional journals and standards when their level of use makes it profitable. Commercial data bases now provide chemistry, engineering, materials science, physics, and worldwide patent information; information on new technologies; and foreign research results.
- The interdisciplinary nature of research is growing, making STI from outside one's own research community more critical.
- Although RECON should contain citations to NASA-sponsored research reports, these reports sometimes miss the RECON input stream. The greater credibility of research efforts published in peer-reviewed journals, and the speed with which journals go to press (enabling the researcher to establish priority of discovery), encourage publication outside the NASA STI publication system. This trend will continue.
- The United States was the leader in development of on-line data sources and in utilization of commercial data bases. In recent years, several international initiatives have created a demand, and sources to fill it, for on-line data sources outside the United States. More – and more valuable – data sources will emerge overseas. Researchers are aware of probable data sources but do not yet have the contacts to exchange data with foreign peers on a scale similar to that of peer exchange within the United States.

Conclusion: There are sources with the potential to satisfy users' STI needs in the near term, but effective use of those sources is hindered by diverse factors. These factors are discussed below:

- *Internal Sources*

- ▶ RECON will continue to lose credibility as a comprehensive source of STI for NASA users. Users' perceptions of gaps in RECON coverage result from a lack of clear policy regarding acquisition and coverage of subject areas.
- ▶ Internal nonbibliographic information sources will proliferate but will not be centrally administered, making it difficult to locate the best source for a particular researcher.
- ▶ Some internal sources can be located and classified by research community (for example, PLDS, NODS, PDS, ADS, and EOSDIS), but many researchers are currently unaware of these systems, even when the systems are within their research community, and many systems will remain below the level of public awareness.

- *External Sources*

- ▶ More sources that are superior to an internal NASA bibliographic data base will become available. More sources of nontextual information, such as standards and specifications, will be available.
- ▶ More full-text sources of journal literature will become available. Currently, STN provides full-text files of 31 journals and periodicals covering chemistry.
- ▶ With proliferation of sources, the problem becomes one of assembling the best set of sources to meet diverse research needs.
- ▶ NASA must provide a mechanism to maintain the best combination of sources for the users' requirements. Post-processing of query results (for example, elimination of duplicated citations) must be provided, along with relevancy ranking. Because of the increased use of "buzzwords" in reports of low information value, relevancy ranking should be based on sponsor and author as well as term frequency.

Action Items 3 and 4: Include in the gateway prototype the applications most frequently requested by users. There should be a two-level user interface: one level for end users and one for NASA library staff. Base the prototype in Center libraries and selected end-user offices.

Conclusion: A gateway implemented in the near future can assist in program planning for STI.

- The RECON system has not provided statistics identifying the query traffic against a certain subject area or discipline by user or research community. A gateway system can capture, by user, the queries of sources related to a specific discipline or subject area. Use for a 6-month period could identify those subject areas in need of augmentation. Potential responses to those identified weak areas include changes in RECON acquisition policy or a decision to use outside sources to supplement RECON coverage in an area.
- A gateway will allow STI users to evaluate STI sources. Users can communicate via electronic mail to the STI Division their judgments of the validity and utility of the STI available from each source. This evaluation can be continued beyond the prototype test period to provide a mechanism for continuing involvement of users in the STI acquisition and quality control process at NASA.

Conclusions: Patterns of STI search behavior will change over the next 5 years. End users will make a gradual transition to becoming more active direct searchers of on-line STI.

- For the near term, NASA researchers will continue to use library staff for on-line queries that are iterative.
- Internet use will increase; end users will locate peers with similar research interests, communicate electronically with those peers, and exchange STI with them.
- Reference librarians, as trained search intermediaries, are already comfortable with multiple STI sources. They would retrieve a greater variety of STI if availability of new sources were stable and connection to them were made simpler.
- Researchers have a wide range of skills with automated systems.
- Researchers are ready to use specific applications for direct access.

- Researchers do not want to become expert searchers on a variety of systems/sources. Most will continue to use intermediaries for complex searches for the near future, with a gradual increase in direct use, although a few STI users are ready to use a sophisticated gateway now.
- NASA is becoming a younger agency; over the next 5 years, the STI Division must provide more capability to locate, access, and retrieve STI directly for these users.
- Experience would improve end users' ability to articulate long-term requirements for the STI delivery system.
- Librarians are professional users of on-line information and, as professional search intermediaries, can best evaluate the functions of the gateway that assist users in formulation of effective queries.
- NASA researchers are comfortable with computer tools; the limits on direct use of STI are (1) knowledge of sources and their relative utility and (2) the time required to become an effective user of diverse on-line STI systems.

Action Item 5: Using existing networks, provide simplified, reliable telecommunications paths connecting user workstations, the gateway host, and remote sources.

Conclusion: The various workstations in user locations can be used in gateway access to STI.

- Users have a variety of personal computing environments available to them. Researchers have UNIX-based workstations, Macintosh workstations, and MicroSoft-Disk Operating System (MS-DOS)-based personal computers, while library personnel have MS-DOS-based personal computers.
- A prototype gateway developed under UNIX would support these diverse personal computing environments. Users who have MS-DOS computing environments can use a terminal emulation to access the gateway host. Those with compatible UNIX-based workstations may have some of the gateway functions installed on their workstations, and other functions on the gateway host.

Conclusion: Navigating the multiple networks between the user and the desired STI source discourages users at both the end-user and information-broker levels.

- Telecommunication is frequently a major barrier to sharing of STI maintained by one's peers. Sources can sometimes be found through telephone contact with the research or library community. Once a source is

located, there are frequent problems with making the connection and transferring STI.

- Multiple networks in the path from user to source multiply the points at which the connection or data transfer can fail, often because of incompatibility in applications or communications software.
- The gateway provides telecommunications connections that are invisible to the user; if links in this connection are unreliable, the gateway is unreliable.

Conclusion: Existing NASA networks, both LANs and wide area networks, offer capacity for gateway communications but vary in reliability and accessibility. These networks could be supplemented by a single commercial system leased for the duration of the prototype test.

- At most of the NASA Centers visited, facility-wide networking is starting to mature. Many users interviewed are becoming connected to these LANs and familiar with their operation.
- Center LANs, as providers of a common interface and existing distribution network, would be the ideal means by which a mature gateway could be made available to the most users and could develop a facility-wide impact.
- The suitability of a LAN connection for prototype users must be evaluated on a LAN-by-LAN basis. Some users are connected to suitable LANs, while others are not; where a LAN connection is feasible, it is preferable, because the user will be able to use a familiar access path.
- One candidate for the wide area network connection to the gateway host is Program Support Communications Network (PSCN), because of its connectivity. However, PSCN has been unreliable in the past.
- Enhanced capabilities provided through gateway features will increase the demand on lines to data sources; in some cases, it would be best to have a dedicated line from the gateway host to a data source.
- An optimal communication configuration would allow predefined paths to each STI source, to be set up with selection based on factors such as cost, transfer speed, and availability. In the event of failure of a single path, an alternative means could automatically be selected.
- Close coupling of the gateway with the library would allow the largest initiator of searches to have the readiest access to the sources without imposing additional communications overhead.

Conclusion: Gateway connection to Internet resources is a user requirement; providing Internet connection to gateway resources may also be useful.

- NASA researchers utilize multiple networks in their research efforts; a significant number of researchers are frequent and sophisticated users of Internet. Through this network, it would be possible to reach a number of users who might otherwise be bypassed if connectivity is based on the Center's main LAN.
- Internet would also provide a standardized interface that is familiar to users and readily built into the gateway. It would also allow gateway access to the larger research world, for potential information exchange.
- A simple Internet interface could be the standard electronic mail format; queries and results could be packaged to operate in this environment.

In summary, the NASA environment presents a complex array of networks and equipment. Rather than be seen as an obstacle for the gateway, this diversity should be viewed as an opportunity to provide (1) increased capability to the NASA community and (2) more direct paths and procedures to access that capability.

Action Item 6: Include all organizations that participate in STI delivery and use in gateway development.

Conclusion: Since the STI delivery function has not been comprehensively evaluated in 20 years, the STI Division is out of touch with the STI user community.

- No functioning mechanism exists for STI users to communicate needs or priorities regarding the STI delivery system or to get problems resolved.
- The Center libraries are good liaison points for the STI user community. The library staff understands the end users' environment and can assist in evaluating STI requirements.
- There should be regular coordination between the STI Program and the library staffs regarding the STI sources available and the STI delivery system. The library staffs should be viewed as partners in the delivery of STI, and their recommendations should be responded to.
- There is little awareness in the STI user community of the authorities and responsibilities of the STI Division.
- The portions of the STI Division's strategic plan that talk to a customer focus are critically important. The channel for this customer dialogue should be established and should be maintained indefinitely.

- Library staffs maintain a high level of professional service as a result of lateral communication but need access to Headquarters for policy guidance and advocacy.
- Center libraries need recognition by NASA budget authorities that they provide critical support to the research process; research organizations should be able to fund access to commercial data bases when they have a special requirement.
- Library staff are perceived by the research communities as the focal point for STI at the Centers; they will continue in this role for the foreseeable future.
- The Center libraries need more control of the resources they use to deliver STI. There have been mid-year stoppages of both on-line commercial STI source access and the *Scientific and Technical Aerospace Reports*, with no notice to the libraries.
- A major limitation on use of commercial sources is the library budget for access to commercial data bases. These are proven sources of STI that support research effectively; yet the funding for access to them comes from an administrative funding category, is not controlled by the users of the sources, and may be cut off mid-year without prior notice. Researchers have tried to fund additional access through the library but cannot transfer their funds to an administrative funding category.
- Research organizations sometimes have contractors perform literature searches because they cannot access the needed source through the library. In these cases, the knowledge gained is not made available to the larger Center community.
- Center library staff would access on-line STI sources more frequently if they had stable access to more sources and if there were more flexibility in the budgeting for on-line access.
- End users will continue to prefer intermediaries for all but fairly simple searches.
- As NASA grows "younger" in the next 5 to 10 years, end users will increase direct use of on-line sources of STI.

CHAPTER 5

DISCUSSION OF FINDINGS

The specific objective of the study described in this report (see Chapter 1) was to assess the potential for an intelligent gateway to meet NASA users' requirements for on-line STI outside of the RECON system. A broader objective was to support the NASA STI Division in its endeavor to improve the STI Program through a focus on the customer. An understanding of the customer's environment requires a more general discussion of the factors that shape that environment, a discussion not limited to those factors directly affecting the delivery of on-line STI outside of RECON. This chapter provides that discussion.

IDENTIFICATION OF THE USERS OF NASA STI

The Function Directly Supported by STI is Research; the User Community is NASA-Sponsored Researchers.

Functions supported by STI are the conduct of general research; the intermediate, iterative research conducted in the context of development (including test and evaluation); and the management of research.

These research functions are performed by NASA scientists, engineers, support service contractors, and principal investigators. They are also performed by university researchers, commercial aerospace R&D centers, and researchers in other federally sponsored research centers. However, the researchers performing NASA-sponsored research are most dependent on NASA's STI delivery system; other researchers typically get their primary support from another system. Since those performing NASA-sponsored research are the users most directly affected by changes in NASA's STI delivery system, we will focus on this group as the primary market for NASA STI. Researchers not sponsored by NASA will have similar functional requirements for access to NASA STI and should therefore be well supported by any system that meets the NASA researchers' requirements.

NASA researchers may search for STI directly or may ask for search support from NASA librarians. The most common scenario is a combination of the two: the

researchers frequently use peer contacts to locate STI, while the librarian searches other sources.

Research functions are the most dependent on STI for their success. STI supports basic research, specific research at proposal initiation, specific research when unexpected intermediate results are encountered, writing the report of the research project, and development of prototypes or experimental models. Support to basic research includes identifying and locating the critical references in one's field, building one's personal library, and maintaining a level of expertise and awareness in related subjects. In proposal initiation, the researcher uses STI to ascertain that the research is original, to determine what related research has been done or is being done by others, and to decide whether their research obviates the need for his planned project. A search of relevant STI at this stage can help with hypothesis generation and the location of supporting evidence and provide names of peers useful as contacts.

When unforeseen results are encountered during research, information retrieved from STI sources may help the researcher modify hypotheses or otherwise fit the new information into the project context. When the researcher is ready to write the report of the research project, STI is needed to provide references and a model of how similar reports are structured. During prototype development, STI is needed to find sources of needed components, to research patent information, and to generate new design concepts.

The management of research requires both STI and administrative information. This function is performed by technical project managers (TPMs) who usually come from the ranks of senior researchers and those higher in the Center's research management structure. These managers need STI that qualitatively describes research, and in that requirement they are similar to the NASA researcher population. They also need to link retrieved STI to information that quantitatively describes the research program – typically budget information at the Center and agency level. Managers may also wish to track legislative action. Some NASA research managers request this type of information through the Center library; most use other sources. This function is less dependent on STI for its successful execution.

The Composition of the NASA Researcher Population is Changing.

An additional aspect of the NASA research community that must be considered is the distribution of employee age and years of experience. The current profile of

NASA scientist and engineer employees is bimodally distributed by age, with more than a third less than 35 years old. Projections by the NASA Office of Personnel Management show the NASA scientist and engineer corps composed mostly of employees less than 45 years old in the next 5 to 10 years. The fact that NASA is becoming a younger agency has implications for the NASA STI delivery system regarding the way STI is provided now, in the next 5 years, and in 5 to 10 years.

One implication is that much of the corporate memory in NASA will retire over the next 10 years. We have been told by NASA STI users that peer contact is critically important in locating the right scientific and technical information with the current delivery system. When many of those peers retire, the remaining researchers will be handicapped in locating STI, and utilization of previous research will become more difficult.

A second implication is that the user population in 5 to 10 years will have much higher expectations of the STI delivery system. Many of the long-term users of the current STI delivery system have developed auxiliary methods of locating STI and incorporated them into their research strategy. These coping mechanisms are such a part of their work habits that the limitations of the delivery system are no longer obvious to these users. Newer researchers will not have well-developed auxiliary sources of STI and will have to rely on the delivery system. Also, these users will be very computer-literate and will have recently performed research with the aid of their university library systems.

The User Community for STI is the Research Community and the Information Brokers Who Support the Researchers.

Two analyses of the user community are needed: one that defines the level of assistance a group of users will require to access, retrieve, and use the STI and one that defines the type (or subject matter) focus of the STI needed in common by a user group.

The first analysis will allow us to determine the number of user interfaces needed and the types and levels of assistance each interface must provide.

The second analysis will allow us to group users according to a common need for access to a given source of STI; in turn, this will allow us to define the communication paths needed between users and STI sources.

When an analysis is performed of the levels of assistance needed, users fall into two categories: those who have little experience searching on-line data sources and those who are experienced on-line searchers. For the most part, people who are performing the research directly are in the first category; their time is devoted to maintaining a level of expertise in their research subject area, not a level of expertise in on-line searching. We refer to these STI users as "end users," since they frequently use an information broker to obtain the needed STI, and at the end of the search and retrieval process, they apply the STI to their research. End users are

- NASA engineers/scientists
- TPMs
- Contract researchers
- University researchers
- Industry R&D community.

Those who are experienced on-line searchers are those who frequently access and use on-line sources of STI; most often, they are professional intermediaries between end users and STI sources. They are referred to as information brokers. Information brokers are

- Center librarians
- The STIF under NASA Headquarters
- Industrial Applications Centers
- Technology Utilization Offices
- Centers for the Commercialization of Space.

The interface required by each category of STI user is distinct. The end user typically wants some common searches that can be performed with a few keystrokes. Also, end users state that serendipity is a factor in research; they wish to browse on-line information in much the way they would peruse titles in the library stacks.

IDENTIFICATION OF NEEDED STI TYPES AND RESOURCES

There are Distinct STI Sources and Patterns of Use for Each Category of User.

The following describes, for a user in each category, the sources of STI (in the order of their use) and the typical search activities (presented as steps in chronological order).

End-User Sources in Sequence of Utilization

- First, ask one's peers for good references. This includes remote peers accessed by telephone or electronic mail.
- Use personal, peers', or branch libraries.
- Use Center library resources, including librarian-performed on-line searches.

End-User Search Activities in Order of Execution

- Browse. With peer sources, browsing is sometimes accomplished by putting a message saying: "Can anyone help me locate information on the following subject?" on an electronic bulletin board used by the relevant research community.
- Scan the tables of contents of the set of journals relevant to the research question.
- When a partial citation to a reference is known (author, title, journal, or date, or any combination), find full citation information. Retrieve the reference if possible.
- Find a reference and then find all reference material cited in its bibliography. This action may be applied iteratively to the references retrieved or "backward chaining" through the references.

End-User Search Frequency

Users search, on the average, once per quarter to once every 6 months. The frequency may be affected by the speed with which STI is located and retrieved (some users state that they cannot complete the search and retrieval cycle using current facilities in less than 3 months). It is also affected by the number of projects a researcher can work on concurrently (the average is two or three), the cycle of

searching at project initiation and report drafting stages, and the timing of professional meetings at which researchers wish to present papers.

End-User Retrieval Volume

A useful volume of citations is 20 or less, if the precision of retrieval is high. However, researchers can receive a hundred citations, especially when the information broker has searched the RECON system, or when the search is in an unfamiliar subject area. The researcher then manually identifies the citations to STI that should be retrieved in full text or modifies the search and starts the search process again.

One of the values added by information brokers is their knowledge of the relative utility of a source for a given subject area. Most Center librarians search RECON first; it is the least expensive source, and its Thesaurus and Frequency functions are very useful in helping the librarian find terms to formulate a more precise and complete search. The librarians will search other sources if the RECON result is not satisfactory to the end user, but budgets for subscription data bases are very limited.

Librarian Source Use and Search Activities in Sequence of Execution

- Search RECON, using the Frequency function to determine the best search terms, unless the subject area is one not covered in RECON.
- Search low-cost auxiliary sources (locally installed CD-ROM data bases, ARIN, DTIC/DROLS, RLIN, and other library systems), refining the query as more is learned about the subject.
- Search higher cost subscription data bases (DIALOG, STN).

Librarian Search Frequency

Using statistics maintained by the main libraries of the three Research Centers visited (two maintained on a fiscal year basis, one on a calendar year basis), we calculated the following averages:

- The main libraries of the three Research Centers performed an average of 503 DIALOG searches each during a 1-year period.
- The same three libraries performed an average of 370 RECON searches each for the same period.

Searches are also conducted in various other data bases (DROLS, STN, MEDLINE), but the only use statistics that all three libraries had in common were for RECON and DIALOG. The anomaly of a larger number of high-cost data base searches (when they usually are the last resort) is due to the advantages offered by a number of DIALOG data bases that provide credible coverage of subjects and sources not well covered in RECON or low-cost auxiliary sources. For those subjects, the librarians go directly to the best source for the information.

Librarian Retrieval Volume

The volume of citations retrieved varies depending on the source used; in subscription data base sources, the number of citations is usually low (less than 20), because of the cost of each citation and because of the librarian's use of the best source for the subject area. In RECON, the volume of citations retrieved can be high; one user reported receiving 200 RECON citations in response to a librarian's search. The number of citations and the precision of retrieval depend partly on the user's interaction with the intermediary. If the end user and the intermediary jointly view the intermediate search results, the subject matter expertise of the end user and the intermediary's knowledge of sources and query formulation combine to produce a tightly focused and precise search.

NASA is Not Reaping the Full Benefit of Its Internal STI Resources.

The body of STI produced as a result of NASA-sponsored research (internally developed STI) is one of the most valuable collections of information for NASA's user community. However, this STI is frequently not delivered in a usable format or in a timely manner.

The information that results from NASA-sponsored research should be more valuable to NASA researchers than other collections of STI, because it is focused on the science, technology, and issues of interest to the NASA community. However, this information is frequently not located when it is needed. All internally developed STI should be represented by a citation in the RECON system. It should be located via a RECON search of the appropriate keywords or by a text search of abstracts in RECON. Frequently, the sought-after STI is not located as a result of the RECON search. This can be the result of poor keyword choice or abstract preparation, or the fact that the research product never entered the RECON input stream. Keywords are

usually chosen by authors, abstracts are usually prepared by authors, and authors are not trained in how to choose or prepare these so that retrieval is increased.

STI misses the input stream because authors publish via other means, primarily in the journal of the appropriate professional society or in conference proceedings. Authors prefer this alternative publication path because peer-reviewed journals reach the audience the author wants to reach, increasing the author's network of contacts; peer-reviewed journals have higher credibility than NASA publications, increasing the status gained as a result of publication; a researcher can establish priority of discovery by publishing more quickly in a publication and avoiding NASA's publication standards; and outside the NASA publication process, a researcher can publish in the format most appropriate to the field of study, using formats accepted by the peer community. Presentation of research results at a conference usually delays entry of the STI into the NASA publication process, resulting in less timely location and delivery of much internally developed STI.

Delivery in a usable format is hindered by the storage and reproduction process for NASA STI products. These products may be microfilmed, stored, and reproduced from microfilm when ordered by STI users, or they may be copied from an original paper copy maintained for reproduction purposes. These reproductions are frequently of poor quality; in the case of the nontext portions of the documents, low reproduction quality makes many documents unusable to the researcher. NASA's STI preparation, storage, and reproduction processes and their effects on the utility of the documents delivered to researchers.

Document Preparation and Initial Publication

Text is supplied to the Center's STI production department in a number of ways, usually in electronic media. Where electronic formats are compatible, the author's manuscript is taken by disk and converted to the format used by the Center's STI word processing system. This process is compounded by the enormous differences in hardware and software that exist at all installations. To help overcome the problem, general STI guidelines are maintained at the facilities to control the input document standards. The resulting document must be edited, because of local STI format standards and the inexact nature of most conversion routines. Where a non-electronic manuscript is provided, the STI production department enters it into its internal system either manually or through a scanning process.

For photographs, the author typically provides camera-ready copy to the STI production department or makes the same arrangements with the graphics branch. General policy is to discourage use of color because of its high cost.

Drawings, graphs, and diagrams are supplied in original form by the author. Depending on the desired quality and the final document category, the facility graphics department can then arrange to have a technical illustrator produce a final version.

Entering formulae into most word processing programs can result in publication of formulae that are clumsy looking, especially when complex. Specific representations of mathematical symbols may vary by author and by discipline. To satisfy these various demands, the Center STI office must frequently typeset formulae and insert them into the finished manuscript.

Document Distribution and Storage

After publication by the local center or the Government Printing Office, final documents are provided to the author and the persons or agencies on the approved distribution list. The RECON archival copy is sent to the STIF in Maryland, where it is stored on microfiche.

Document Retrieval and Reproduction

After the limited stock of the first printing is exhausted, subsequent requests for copies of a document are satisfied through microfiche or reproductions from microfiche. This process, especially with the reproductions, has considerable drawbacks. Finely typeset symbols or numbers such as are found in formulae, tables, and scales are frequently difficult to read (see Figure 5-1). More importantly, color or grey scale graphs and photographs are totally illegible, with a resulting loss in obtainable data. Figure 5-2 shows the reproduction of a color graph with its temperature scale. Even straightforward black-and-white photographs do not survive the process well.

STI is Needed in Formats Other Than Text.

The traditional view of STI is restricted to text only; the RECON system contains only bibliographic citations to text articles and reports. However, users

have stated that the nontext portions of documents contain critical information. Delivery of this STI differs from the delivery of text.

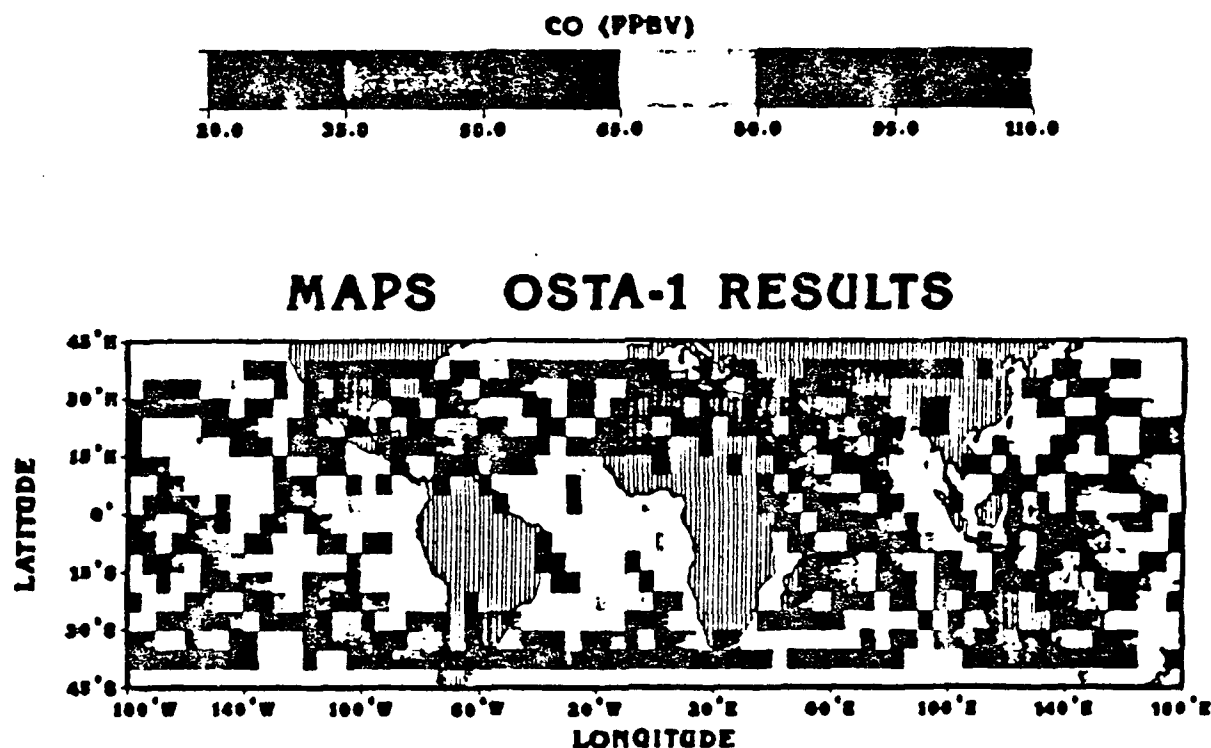


FIG. 5-1. FINE TYPE IS LOST IN REPRODUCTION PROCESS

Photographs

These can be both color or black-and-white images. Field interviews indicated that about half of the reports produced contain photographs, with an average of three images per report. As could be expected, these photographs are derived from a variety of sources. An important issue is their function in the document. Rather than simply act as a supporting component of a technical paper, photographic images are becoming one of the primary means of displaying experimental results. Examples of this trend are found in microstructure research and water tunnel testing. Many photographs that originate from computer enhancement, such as map

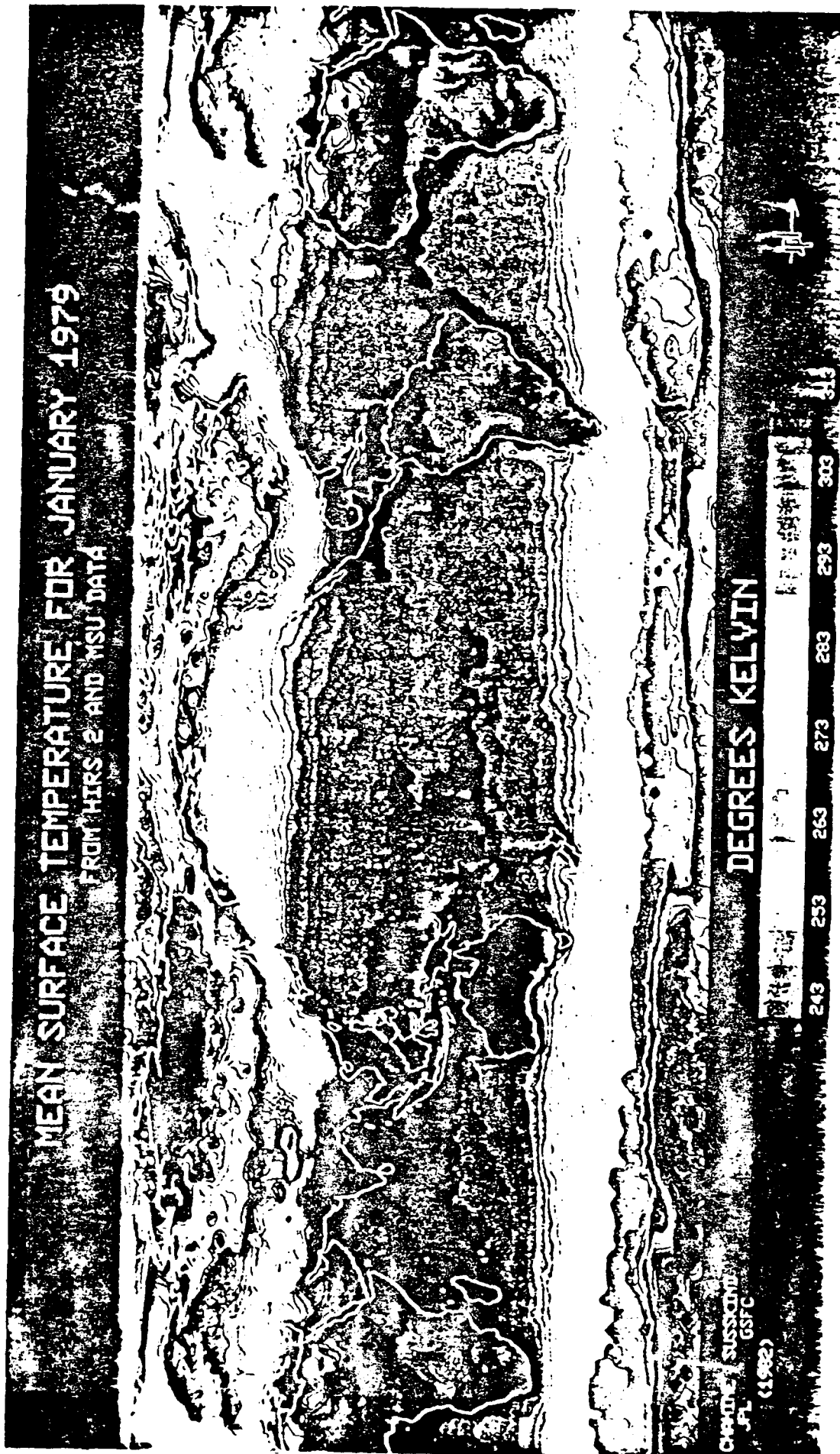


FIG. 5-2. COLOR IS LOST IN REPRODUCTION PROCESS

overlays of environmental measurements, also include color or grey scales for interpretation. Fidelity in reproduction of photographs and scales is of critical importance in STI delivery.

Drawings, Graphs, and Diagrams

These are encountered in most technical papers. Graphs, with their attendant scales, are probably the most common way of presenting experimental results. Drawings and diagrams can be used to display various concepts, from equipment designs to chemical relationships. Although most such graphic work is in black and white, higher quality documents sometimes incorporate color, not for its visual appeal, but to convey complex information. Like photographs, graphs that result from computer generation frequently feature color scales for interpretation; the loss of color in reproduction makes the document almost useless.

Formulae

Formulae can be viewed as a subset of text. They are frequently complicated in layout because they contain special mathematical symbols, exponential characters, and layering that cannot be accommodated by most word processing packages. The interest of the author is also of importance here. Often the entire thrust of a paper can be represented by a single formula. Any experienced student is aware of the mathematician's regard for elegance in his results. This applies to their appearance as well as their content.

Tables

Tables normally are straightforward incarnations of text and simple line graphics. They can vary, however, depending on the application. Some tables contain embedded formulae, especially in the context of complex matrix representation.

Numerical Files

The ability to locate and capture numerical files allows researchers to reuse physical tests of many types. This is true of wind tunnel tests, destructive and nondestructive materials tests, etc. Reading the data reports of such tests is useful; the ability to re-analyze the test results from a different perspective saves duplicative, resource-intensive physical test and observation activities. Specifically, when a researcher is building a model of a physical phenomenon, data from an observation of

that phenomenon can be used to validate the model. The current effort to provide an improved numeric data locator must incorporate the researchers' views of this data.

Researchers have expressed some reservations about putting the numerical files that result from physical testing or observations of physical phenomena into a system for general consumption. These numerical test results could be badly misapplied or misinterpreted, causing the original researcher to regret having made them available. However, some researchers have stated that the data report should adequately describe the original test's purpose, structure, and conditions, to allow later researchers to evaluate its applicability to a new research project. The data report should also adequately describe the observation paradigm and data reduction or other operations performed to produce the data set, to allow the data to be reused appropriately. If the numerical data set were retrievable only via the data report, most of the researchers asked agreed that that would be adequate to ensure correct interpretation of the data.

Other researchers have reservations about the size of these files; matrices can be hundreds of thousands of cells in a dimension. Such files represent a large investment in data capture and should be made available for consideration for reuse. Perhaps they could be included in a directory of such files with a high potential for reusability.

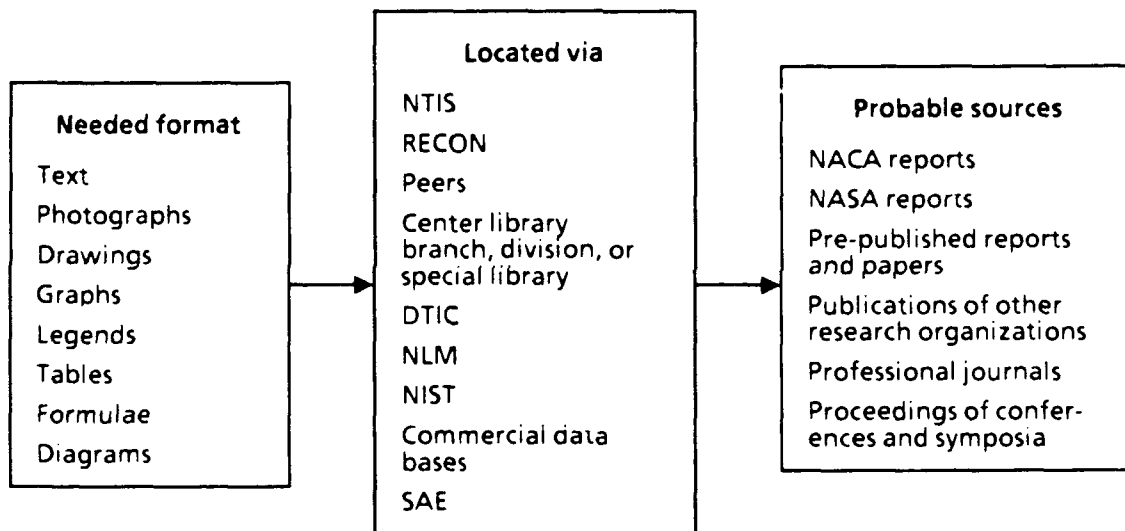
IDENTIFICATION OF STI DELIVERY SYSTEMS

Peers Are an Important Part of the STI Delivery System, Especially Useful in Locating STI Focused on One's Research Area and Maintained in Decentralized Locations.

Users with a common need to access a source are usually members of a group with similar research interests. These "research communities" share a common research focus, academic discipline, or group of related disciplines. They cross organization and political boundaries, and each has some core STI requirements that are common within the community. The core requirements have to do with the type of STI needed, the source access needed, the STI format, and the way the STI will be used once it is retrieved. The research community's perspective and input will be invaluable in assembling a set of STI sources that best meets a researcher's needs and conforms to the researcher's view of the world.

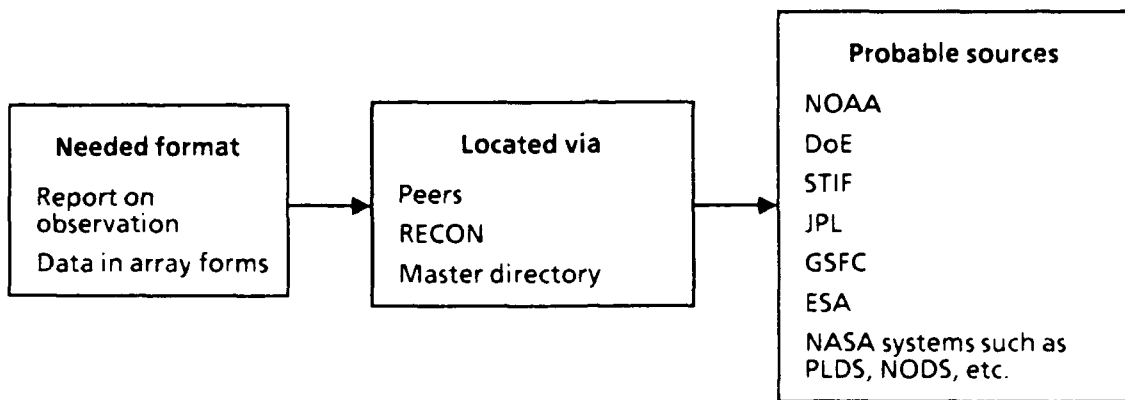
Users Have Identified Types of STI, Needed Formats, and Probable Sources of Required STI as Follows:

- Text of articles, reports, conference papers, dissertations, and theses. The most desirable is retrievable full text of the original document (see Figure 5-3).
- Observation data, if retrieved with the reports written about the observations (e.g., physical testing, planetary observation) (see Figure 5-4).
- Graphic images (see Figure 5-5).
- Computational tools (see Figure 5-6).
- Video images (see Figure 5-7).



Notes: NTIS = National Technical Information Service; NLM = National Library of Medicine; NIST = National Institute of Standards and Technology; SAE = Society of Automotive Engineers; NACA = National Advisory Committee for Aeronautics

FIG. 5-3. TEXT IN DOCUMENT FORM



Notes: NOAA = National Oceanographic and Atmospheric Administration; DoE = Department of Energy; JPL = Jet Propulsion Laboratory; GSFC = Goddard Space Flight Center; ESA = European Space Agency

FIG. 5-4. OBSERVATION DATA

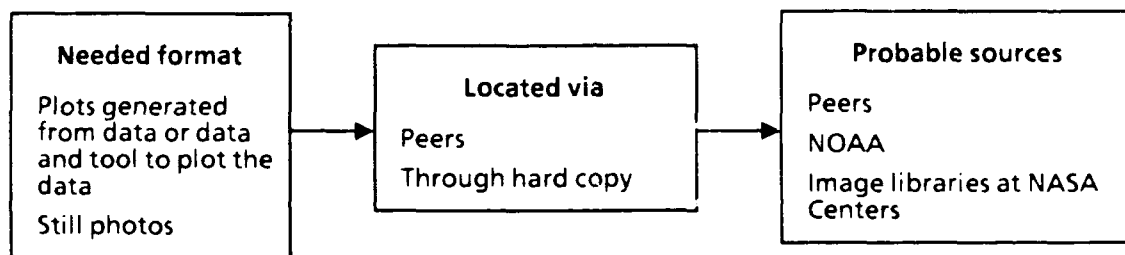
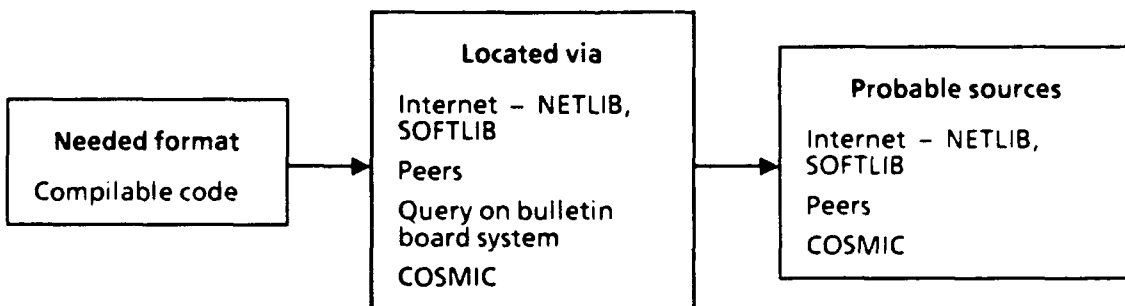


FIG. 5-5. GRAPHIC IMAGES



Notes: NETLIB = Internet's Mathematical Software Distribution system; SOFTLIB = Software Distribution System on Internet; COSMIC = Computer Software Management and Information Center.

FIG. 5-6. COMPUTATIONAL TOOLS

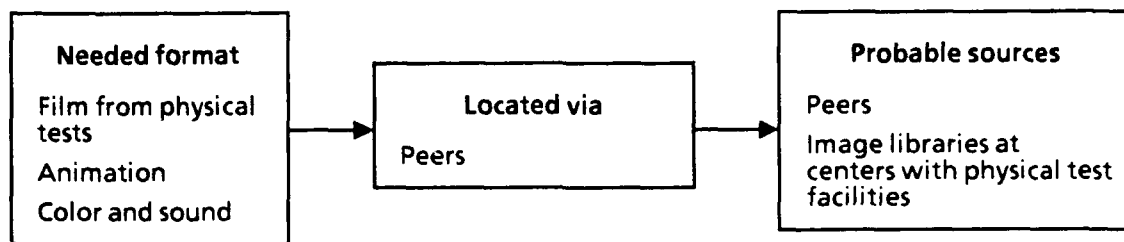


FIG. 5-7. VIDEO IMAGES

An Improved Delivery System Would Make These Sources Equally Accessible.

Peers outside the NASA user community are usually located through the research community contacts. Difficulty of telecommunication is similar to that found among peers within NASA. A major difference is in the number of international, as opposed to domestic, peer contacts. It is much more difficult for NASA researchers to make and maintain international contacts. For example, although a researcher may be aware that the European Community is performing research of interest in her discipline, she has no contacts in that organization and cannot determine which research center is performing the work. The same is true for European space Agency (ESA), *Office National d'Etudes et de Recherches Aeronautiques* (ONERA), Soviet, and Japanese research centers, all of which have been cited as needed international sources by researchers who had no peer contacts at those organizations.

Libraries are readily available, usually a maximum of a 15-minute walk from the researchers' offices. However, some users state that leaving the building to go to the library is a barrier to use and lowers their use of that resource. Personal, branch, division, and speciality libraries are frequently used instead.

RECON access is easily obtained, usually through the Center library. Researchers can obtain user accounts to access RECON directly. Twenty to fifty percent of users who obtain passwords remain active searchers; the rest use the system very little, or revert to having the librarian conduct searches for them.

Other U.S. Government on-line sources are usually accessed through the Center library. Sometimes, these sources are available through the research community,

and librarians are not aware of them. In that case, researchers access directly; peers play a role here.

Commercial data base access is limited by library budget constraints not under the library's control. Researchers depend on these auxiliary sources, and periodic denial of access is a problem. Some research organizations have responded by directly funding access and performing searches themselves or by contracting directly for literature searches with service support contractors. Even with budget limitations, expensive commercial data base use is higher than free RECON use at the three Research Centers visited. Some reasons for this anomaly are that these data bases provide coverage in areas where RECON coverage is weak; these sources are very flexible, rapidly developing new data base offerings to cover new technology; and many of the technical data bases are developed by professional societies, so that the data have high credibility with the research community. Researchers who have directly funded data base subscriptions and perform searches themselves prefer the search interface associated with the commercial systems. For example, the ability to search by a chemical structure diagram from a standard personal computer or terminal is one of the strengths of STN. STN also offers the full text of journal articles on line, as an alternative to a bibliographic citation.

There Are Organizational and Budget Constraints That Affect Prototype Development and Implementation of the STI Division Strategic Plan.

The organizations involved in STI delivery are NASA Headquarters STI Division, Center libraries, and research organizations. For the past 10 years, there has been little or no communication among these organizations for joint planning of research and its support – STI Division initiatives in the past year, including this study, are part of the Division's attempts to change this situation.

Research staffs at the NASA Centers understand the connection between library services with successful R&D activities. When there were insufficient funds in the library budgets for commercial data base use, researchers at two Centers tried to transfer funding from their organizations to their Center's library budget. But such transfers are impossible because the funding categories for the libraries and research programs are different. This is one reason why research organizations have funded literature searches by support service contractors. The policy issue involved here needs consideration at the Headquarters level. However, the apparent channel for communications regarding such policy matters – the Headquarters STI

Division – has been staffed at such a low level that it has been unable to serve as a point of contact for their resolution.

The Center librarians communicate regularly with one another, and their peer network compensates somewhat for the lack of dialog between Center libraries and Headquarters. Nevertheless, a Headquarters contact for guidance and advocacy is needed. The lack of an established relationship between the libraries and the STI Division will inhibit diffusion of the strategic vision to the Center.

End users are part of the delivery system in that they frequently locate and retrieve STI from their peers and from peers' systems. These end users are "gatekeepers," users who maintain a very effective network of contacts, know STI sources, and may be skilled in location and retrieval of STI. They would be valuable sources of information regarding STI from peer sources and nontextual STI. Their participation in the STI Division's initiatives will be constrained by organizational barriers.

Budget constraints on the STI Division will inhibit gateway development. For example, some STI formats such as video images that the R&D community would like to access may not be addressed for some time, because of financial – not technological – constraints. The lack of recognition of STI's impact on R&D also constrains STI delivery. The R&D community's access to STI outside of RECON is budget-constrained, and the fact that R&D budget money cannot easily be transferred to budgets supporting NASA library and STI activities makes it difficult for STI delivery system customers to support such endeavors as a gateway.

GLOSSARY

ADS	=	Astrophysics Data System
ARIN	=	Aerospace Research Information Network
COSMIC	=	Computer Software Management and Information Center
CD-ROM	=	Compact Disc Read Only Memory
DIALOG	=	Dialog Information Services, Inc.'s on-line data base collection
DoD	=	Department of Defense
DoE	=	Department of Energy
DROLS	=	Defense RDT&E On-Line System
DTIC	=	Defense Technical Information Center
EOS	=	Earth Observing System
EOSDIS	=	Earth Observing System Data and Information System
ESA	=	European Space Agency
GSFC	=	Goddard Space Flight Center
JPL	=	Jet Propulsion Laboratory
LAN	=	local area network
MEDLINE	=	biomedical literature data base produced by the National Library of Medicine
MS-DOS	=	MicroSoft-Disk Operating System
NACA	=	National Advisory Committee for Aeronautics
NASA	=	National Aeronautics and Space Administration
NASP	=	National Aerospace Plane
NETLIB	=	Internet's Mathematical Software Distribution System
NIST	=	National Institute of Standards and Technology
NLM	=	National Library of Medicine

NOAA	=	National Oceanographic and Atmospheric Administration
NODS	=	NASA Ocean Data System
NTIS	=	National Technical Information Service
ONERA	=	<i>Office National d'Etudes et de Recherches Aerospatiales</i>
PDS	=	Planetary Data System
PLDS	=	Pilot Land Data System
PSCN	=	Program Support Communications Network
R&D	=	research and development
RECON	=	Remote Console
RLIN	=	Research Libraries Information Network
SAE	=	Society of Automotive Engineers
SOFTLIB	=	Software Distribution System on Internet
STI	=	Scientific and Technical Information
STIF	=	Scientific and Technical Information Facility
STN	=	Scientific and Technical Information Network
TPM	=	technical project managers

APPENDIX

SCOPE AND METHODOLOGY

This study was chartered to determine the requirements for access to on-line scientific and technical information (STI) outside of the Remote Console (RECON) system, with the intention of providing access to needed STI via a prototype intelligent gateway. Most of our information on which this report is based was derived from interviews. In this appendix, we detail the scope of the National Aeronautics and Space Administration (NASA) user population interviewed and the methodologies used to analyze our findings.

SCOPE

Sample Versus the Total User Community

Three NASA Centers agreed to participate in the prototype analysis: the Ames, Langley, and Lewis Research Centers. Initial contact was made with the Goddard Space Flight Center to gather information about NASA users and the existing STI delivery system. User interviews were coordinated through the STI managers at the three Research Centers and included the library staff, the STI production staff, and end users selected by the Center coordinator. The end users interviewed do not constitute a representative sample of the STI user population of NASA as a whole.

To understand how the users we interviewed would correlate to the total user population, we requested a data retrieval from the personnel system of the Office of Personnel Management at NASA Headquarters. The data showed numbers of employees engaged in research, design, development, and test/evaluation functions at NASA Research and Space Centers, with degrees in relevant disciplines. Analysis of the data shows that the Centers we studied over-represent the research function and under-represent the design, development, and test/evaluation functions. In terms of academic disciplines, the electrical, electronic, and communications engineering; general physics; computer and information science; and civil, construction, and transportation engineering disciplines were under-represented.

These differences should be borne in mind when considering the results of this study and their application to a NASA-wide system. These different disciplines will require different sources of STI. Their application further "downstream" in the R&D process will require a different mix of information, with heavier use of standard specifications, patent information, and applications of technology to new products.

Functions Covered

Interviews at the three Research Centers were coordinated by the STI manager at each Center, with the aim of representing the potential user community for STI. As previously noted, at every Center, we interviewed library staff and the STI managers and staff. Among NASA employees and support service contractors, we interviewed in the following areas:

Goddard Space Flight Center

- Management Operations Directorate
 - ▶ Information Management Division
 - Library Services Branch
 - Graphics and Publication Services Branch
 - Automation Planning Branch
- Earth Sciences Directorate
 - ▶ Space Data and Computing Division
 - Central Data Services Facility
 - Data Management Systems Facility

Jet Propulsion Laboratory

- Library Staff

Ames Research Center (Dryden)

- Office of the Director of Flight Operations and Research
 - ▶ Dryden Aeronautical Projects Office

- ▶ **Research Engineering Division**
 - Flight Systems Branch
 - Fluid and Flight Mechanics Branch
 - Integrated Test and Simulation Systems Branch
 - Vehicle Technology Branch
 - Aerostructures Branch

Ames Research Center (Moffett)

- **Office of the Director of Aerophysics**
 - ▶ **Information Sciences Division**
 - Division Chief, Information Sciences Division
 - Advanced Mission Technologies Branch
 - ▶ **Fluid Dynamics Division**
 - Fluid Dynamics Research Branch
 - Computational Physics Section, Computational Fluid Dynamics Branch
 - Applied Computational Fluids Branch
 - ▶ **Thermosciences Division**
 - Thermo-Physics Facilities Branch
 - ▶ **Numerical Aerodynamic Simulation (NAS) Systems Division**
 - NAS Applied Research Office
 - NAS Systems Development Branch
- **Office of the Director of Space Research**
 - ▶ **Space Science Division**
 - Planetary Biology Branch
 - ▶ **Life Science Division**
 - ▶ **Advanced Life Support Division**
 - Extra Vehicular Systems Branch

- Office of the Director of Aerospace Systems
 - ▶ Aircraft Technology Division
 - Civil Technology Office
 - ▶ Full-Scale Aerodynamics Research Division
 - Rotorcraft Aeromechanics Branch

Lewis Research Center

- Aeronautics Directorate
 - ▶ Propulsion Systems Division
 - ▶ Instrumentation and Control Technology Division
 - Research Sensor Technology Branch
 - ▶ Internal Fluid Mechanics Division
 - Aerothermochemistry Branch
- Aerospace Technology Directorate
 - ▶ Structures Division
 - Fatigue and Fracture Branch
 - ▶ Division Chief, Power Technology Division
 - ▶ Materials Division
 - ▶ Engine Materials Project Office
 - Surface Science Branch
 - Polymers Branch
 - Advanced Metallics Branch
- Space Flight Systems Directorate
 - ▶ Space Experiments Division
 - Microgravity Combustion Branch

Langley Research Center

- Office of the Chief Scientist

- Office of the Director for Electronics
 - ▶ Instrument Research Division
 - Nondestructive Measurement Science Branch
- Office of the Director for Structures
 - ▶ Materials Division
 - Mechanics of Materials Branch
 - Applied Materials Branch
 - ▶ Acoustics Division
 - Structural Acoustics Branch
 - Applied Acoustics Branch
 - ▶ Structural Dynamics Division
 - Spacecraft Dynamics Branch
 - ▶ Structural Mechanics Division
 - Computational Dynamics Branch
 - Aircraft Structures Branch
- Office of the Director for Aeronautics
 - ▶ Applied Aeronautics Division
 - Subsonic Aerodynamics Branch
 - ▶ Fluid Mechanics Division
 - Chief Engineer
 - Computational Aerodynamics Branch
- Office of the Director for Space
 - ▶ Assistant Division Chief, Atmospheric Sciences Division
 - ▶ Data Management Office
 - Aerosol Research Branch
 - Radiation Sciences Branch

- ▶ Space Systems Division
 - High Energy Science Branch.

METHODOLOGY

The analysis methodology applied to this project combined functional analysis and information retrieval analysis techniques. First we determined which functions performed in NASA might be supported by on-line STI. Then we identified who in NASA performs those functions. When those people were identified, we analyzed the information retrieval requirements of that population, identifying the type of information to retrieve, the retrieval formats, likely sources, and the communication paths needed to connect the user population to STI sources.

Functions found to be supported by STI were the conduct of general research; the intermediate, iterative research conducted in the context of development; and the management of research.

The first two functions are performed by NASA scientists and engineers who may search for STI directly or ask for search support from NASA librarians. (The most common scenario is a combination — the users search for STI among peer contacts while the librarian searches other sources.) The third function, the management of research, requires both STI and administrative information. This function is performed by technical project managers, who usually come from the ranks of senior researchers, and those higher in the Center research management structure. These managers need STI that qualitatively describes research; in that requirement they are similar to the NASA researcher population. They also need to link retrieved STI to information that quantitatively describes the research program; this is typically budget information at the Center and agency level. Some managers also wish to track legislative action. While managers may request this type of information through the Center library, most use other sources.

The information retrieval aspects of supporting these three functions were identified through interviews with engineers, scientists, librarians, and managers. These users of STI identified the types of STI needed to support their functions and the likely sources of the relevant information. They also discussed the formats in which data are required and details of the means by which STI is accessed most effectively.

Information for our analysis was gathered also from literature surveys (for example, the *NASA Research and Technology Operations Plan*); previous studies of the use of STI in similar populations; internal NASA documents describing various data systems under development; interviews with candidate users, STI producers, and STI distributors; and queries of on-line data bases.